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ATV SYSTEM RECOMMENDATION

Federal Communications Commission
Advisory Committee on Advanced Television Service

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Preface

This report, adopted by the Advisory Committee on Advanced Television Service on February 24, 1993, is based on the efforts of hundreds of firms and individuals involved in this project to bring advanced television service to the American public. As a result of the Advisory Committee process, under the leadership of the Federal Communications Commission, it has become apparent that digital HDTV service is achievable for the United States. Indeed, the four digital systems developed under this process lead the world in this technology.

The Advisory Committee wishes to thank all those persons who have played a role in drafting this report and especially wishes to thank the members of the Special Panel for their extraordinary effort in completing the report.

Respectfully submitted,

FCC ADVISORY COMMITTEE ON
ADVANCED TELEVISION SERVICE

By:


Richard E. Wiley, Chairman

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- Narrow-MUSE Record of Test Results**
- DigiCipher Record of Test Results**
- Digital Spectrum Compatible HDTV Record of Test Results**
- Advanced Digital HDTV Record of Test Results**
- Channel Compatible DigiCipher Record of Test Results**

Working Party Reports

- PS/WP1 — Technology Attributes and Assessment**
- PS/WP3 — Spectrum Utilization and Alternatives**
- PS/WP4 — Alternative Media Technology and Broadcast Interface**
- SS/WP1 — Systems Analysis**
 - Technical Critique of the Narrow-MUSE System**
 - Technical Critique of the DigiCipher System**
 - Technical Critique of the Digital Spectrum Compatible HDTV System**
 - Technical Critique of the Advanced Digital HDTV System**
 - Technical Critique of the Channel Compatible DigiCipher System**
- SS/WP2 — System Evaluation and Testing**
- SS/WP3 — Economic Assessment**
- IS/WP2 — Transition Scenarios**

1. EXECUTIVE SUMMARY

This document represents the work conducted to date under the auspices of the Advisory Committee on Advanced Television Service, which was formed in 1987 to advise the Federal Communications Commission on various aspects of advanced television. Through the efforts of hundreds of Advisory Committee participants, particularly those groups which have proposed systems for the Committee's consideration, extraordinary achievements in advanced television have been realized in a very short period. As a result of the Advisory Committee process, under the Commission's leadership, it has become apparent that digital high definition television service is achievable for the United States.

Testing and data analysis recently were completed on five high definition television systems. Previously, in its Fifth Interim Report to the FCC, the Advisory Committee approved a set of ten "Selection Criteria" for use in analyzing the performance of the systems tested. The criteria are grouped into three general categories: spectrum utilization, economics, and technology. In the same report, the Advisory Committee created a Special Panel that would use these criteria to evaluate the performance of tested ATV systems.

The Special Panel met on February 8 - 11, 1993, to consider these matters and to pass a report to the Parent Committee for its consideration. The resulting findings, the bases of which are set forth in Chapter 14 of this document, are as follows:

SPECTRUM UTILIZATION

1. The analysis conducted by the Advisory Committee clearly demonstrates that a substantial difference exists in spectrum utilization performance between Narrow-MUSE and the four all-digital systems. The differences among the four digital systems generally are far less pronounced, however. Based on this analysis, it would appear that Narrow-MUSE will not prove to be a suitable terrestrial broadcasting ATV system for the United States.
2. The Special Panel notes that many system proponents have proposed improvements to their systems in the area of spectrum utilization. The Special Panel finds that the system improvements, primarily those identified by its Technical Subgroup as ready for implementation in time for testing, may lead to improvements in spectrum utilization and should be subjected to testing as soon as possible.
3. The Special Panel finds that the degree of interference from ATV into NTSC, as reflected in the test results and the PS/WP3 report, is recognized as an area of concern in certain markets. The Special Panel finds that the issue of ATV into NTSC interference, including interference to BTSC audio, should be addressed in the remaining stages of the system selection process, including the examination of refined allotment/assignment techniques, the study of possible beneficial effects of system

improvements, and the consideration of any mitigations which might be achieved by transitional implementation policies.

ECONOMICS

1. No significant cost differences among the five proponent systems, either in costs to consumers or to broadcasters, are evident. Thus, based on cost alone, there is no basis to discriminate among systems. However, the additional benefits offered to broadcasters and others by the digital systems were noted as significant.

TECHNOLOGY

1. As a result of the testing process, the Advisory Committee is confident that a digital terrestrial advanced television system can provide excellent picture and sound quality. All of the system proponents have proposed refinements that are likely to enhance the audio and video quality beyond that measured in the testing process.
2. A variety of transmission formats was evaluated. The transmission robustness analysis conducted by the Advisory Committee clearly reveals that an all-digital approach is both feasible and desirable. All of the system proponents have proposed refinements that are likely to enhance robustness beyond that measured in the testing process.
3. An all-digital system approach is important to the scope of ATV services and features and in the areas of extensibility and interoperability. All four digital proponents have committed to a flexible packetized data transport structure and universal headers/descriptors; design and implementation are subject to verification. Progressive-scan/square-pixel transmission is considered beneficial to creating synergy between terrestrial ATV and national information initiatives. As well, scalability at the transmission data stream would permit trade-offs in "bandwidth on demand" network environments.

RECOMMENDATIONS

While all the proponents produced advanced television systems, the Special Panel notes that there are major advantages in the performance of digital HDTV systems in the United States environment and recommends that no further consideration be given to analog-based systems. The proponents of all four digital HDTV systems — DigiCipher, DSC-HDTV, AD-HDTV, and CCDC — have provided practical digital HDTV systems that lead the world in this technology. Because all four systems would benefit significantly from further development, the Special Panel does not recommend any one of these systems for adoption as a United States terrestrial ATV transmission standard at this time. Rather, the Special Panel recommends that these four finalist proponents be authorized to implement their improvements as submitted to the Advisory Committee and approved by the Special Panel's Technical Subgroup.

The Special Panel further recommends that the approved system improvements be ready for testing not later than March 15, 1993, and that these improvements be laboratory and field tested as expeditiously as possible. The results of the supplemental tests, along with the already planned field tests, would provide the necessary additional data needed to select a single digital system for recommendation as a United States terrestrial ATV transmission standard.

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2. INTRODUCTION

The Advisory Committee on Advanced Television Service was empaneled by the Federal Communications Commission in 1987 to develop information that would assist the FCC in establishing an advanced television ("ATV") standard for the United States.¹ The objective given to the Advisory Committee in its Charter by the FCC was:

The Committee will advise the Federal Communications Commission on the facts and circumstances regarding advanced television systems for Commission consideration of technical and public policy issues. In the event that the Commission decides that adoption of some form of advanced broadcast television is in the public interest, the Committee would also recommend

Planning Subcommittee

- PS/WP1 - Technology Attributes and Assessment**
- PS/WP2 - Testing and Evaluation Specifications**
- PS/WP3 - Spectrum Utilization and Alternatives**
- PS/WP4 - Alternative Media Technology and Broadcast Interface**
- PS/WP5 - Economic Factors and Market Penetration**
- PS/WP6 - Systems Subjective Assessment**
- PS/WP7 - Audience Research**
- PS/AG1 - Creative Issues**
- PS/AG2 - Consumer/Trade Issues**

Systems Subcommittee

- SS/WP1 - Systems Analysis**
- SS/WP2 - System Evaluation and Testing**
- SS/WP3 - Economic Assessment**
- SS/WP4 - System Standards**

Implementation Subcommittee

- IS/WP1 - Policy and Regulation**
- IS/WP2 - Transition Scenarios**

The work of the Planning Subcommittee is summarized in Chapter 4 of this report. The work of the Systems Subcommittee is summarized in Chapter 5. The work of the Implementation Subcommittee is summarized in Chapter 6.

The Advisory Committee, in its fifth interim report, approved a procedure for recommending an ATV system. The first step in the process is the determination of the "Selection Criteria." The Selection Criteria constitutes the key issues that must be examined in order to recommend

- Scope of Services and Features
- Extensibility
- Interoperability Considerations

Chapter 7 of this report elaborates on these ten issues, defining them and explaining how proposed systems were measured against the ten criteria. Chapter 8 gives technical details that are necessary for understanding the reported test results on individual proposed systems.

The second step in the recommendation process is the analysis of the proposed systems according to the Selection Criteria. In the subsequent five chapters, each of the proposed five systems is examined according to these criteria. The test information for the examinations came from laboratory testing at the Advanced Television Test Center, Inc. (ATTC), the Cable Television Laboratories, Inc. (CableLabs), and the Advanced Television Evaluation Laboratory (ATEL). Test data was analyzed by the Planning Subcommittee Working Party 3 (Spectrum Utilization Criteria) and the Systems Subcommittee Working Party 4 (Audio/Video Quality and Transmission Robustness). Other substantive information for the examinations came from the Planning Subcommittee Working Party 4 (Scope of Services and Features, Extensibility, and Interoperability Considerations) and the Systems Subcommittee Working Party 3 (Economics Criteria). Information related to improvements which could be made to each of the proposed systems was provided by the Technical Sub-Group of the Special Panel. The system examinations, in the order of testing, can be found in the following chapters:

- Chapter 9 Narrow-MUSE
- Chapter 10 DigiCipher
- Chapter 11 Digital Spectrum Compatible HDTV
- Chapter 12 Advanced Digital HDTV
- Chapter 13 Channel Compatible DigiCipher

Other steps in the recommendation process are the comparison of proposed systems, the determination of a superior system, and the recommendation of a system. The Advisory Committee, in approving the fifth interim report, appointed a Special Panel to make a thorough technical analysis and comparison of the ATV proponent systems and assist the Advisory Committee in preparing its system recommendation. The analyses and comparisons made by the Special Panel² appear in Chapter 14 of this report. In Chapter 14, systems are

² The Special Panel was chaired by Dr. Robert Hopkins. The Vice-Chair was Alex D. Felker. Other members of the Special Panel were Wendell Bailey, Birney D. Dayton, Irwin Dorros, Richard Ducey, Joseph Flaherty, James Gaspar, Branko J. Gerovac, Reggie Gilliam, George Hanover, Dale Hatfield, Edward D. Horowitz, Charles Jackson, Bronwen Jones, Renville H. McMann Jr., Robert Niles, Mark Richer, Robert Sanderson, Rupert Stow, Richard J. Stumpf, Craig Tanner, Victor Tawil, Laurence J. Thorpe, and George Vradenburg III. *Ex officio* participants were the Chairman of the Advisory Committee (Richard E. Wiley), FCC Mass Media Bureau (Roy Stewart), FCC Office of Engineering and Technology (Thomas Stanley),

(continued...)

always listed in the order of testing if no distinction was made in performance. ATV systems that were found to perform in a superior manner are identified in Chapter 14 along with an explanation supporting that finding. Finally, the recommendations made by the Special Panel appear in Chapter 14.

Chapter 15 outlines future work, including field testing and documentation of the recommended ATV system. A glossary, the ATEL comparative report, and the System-Specific Task Force comparative report appear at the end. There are a number of appendices to this report, some of which are rather lengthy. They are available separately.

²(...continued)

NTIA (Tom Sugrue), Department of State (Richard Beird), Canadian Liaison (Kenneth Davies), Mexican Liaison (Victor Rojas), ATTC (Peter Fannon), CableLabs (Brian James), ATEL (Paul Hearty), Field Test Technical Oversight Committee (Howard Miller), System-Specific Task Force (John Henderson), Narrow-MUSE proponent (Keiichi Kubota), DigiCipher proponent (Robert Rast), DSC-HDTV proponent (Wayne Luplow), AD-HDTV proponent (Glenn Reitmeier), and CCDC proponent (Jae Lim).

3. BACKGROUND AND HISTORY

The United States began a proceeding in 1987 which will lead eventually to a new television broadcasting standard. It will be the third American television broadcasting standard. In this Chapter, all three processes are reviewed. For the Monochrome Television Standard and the Color Television Standard, the full process can be reviewed. For the Advanced Television Service, the events that led to the formation of the Advisory Committee on Advanced Television Service and key findings from the five interim reports of the Advisory Committee are reviewed.

3.1 MONOCHROME TELEVISION STANDARD¹

In the late 1930's, as television was nearing the point of commercialization, the members of the FCC insisted that the standards for television, as well as for other services, be set only when the industry was in substantial agreement on the form the standards should take. The FCC had already decided that the channel bandwidth for television would be 6 MHz. The Chairman of the FCC was James Lawrence Fly.

The concept of the National Television System Committee (NTSC) arose in a meeting between Chairman Fly and Dr. W.R.G. Baker, a General Electric executive and director of engineering of the Radio Manufacturers Association (RMA). The NTSC was formed as a private sector organization and placed under the sponsorship of the RMA. The deliberations were open to all members of the industry that were technically qualified to participate whether or not they were members of the RMA.

The original record of the NTSC was 11 volumes totaling approximately 2,000 pages. The first meeting was held July 31, 1940. The final meeting was held March 8, 1941. Dr. Baker served as Chairman of the NTSC. The work of the NTSC was organized into nine panels.

A progress report was presented to the FCC on January 27, 1941. The members of the FCC were satisfied that substantial agreement had been obtained on all parts of the standard except for two points — the specification of 441 scanning lines per frame and amplitude modulation for the synchronization signals.

At its final meeting on March 8, 1941 the NTSC agreed to specify 525 scanning lines per frame and rewrote the portion of the standard concerning synchronization to permit also the use of frequency modulation.

¹ All the information in this section has been taken from Television Standards and Practice (Selected Papers from the Proceedings of the National Television System Committee and Its Panels), edited by Donald G. Fink, McGraw-Hill Book Company Inc., NY, 1943.

The final report of the NTSC was delivered to the FCC on March 20, 1941 recommending adoption of the NTSC standard. The only opposition given to the standard at that time was put forward by the DuMont Laboratories which urged that a variable number of lines and frames per second should be used. Effective April 30, 1941 the FCC officially adopted the standard and ruled that commercial television broadcasting based on the standard would be permitted on and after July 1, 1941.

Key elements of the standard were the use of a 6 MHz RF channel with the picture carrier 1.25 MHz above the bottom of the channel, the sound carrier 4.5 MHz above the picture carrier, VSB modulation of the picture carrier with negative modulation and preservation of the DC component, frequency modulation of the sound carrier, 525 scanning lines per frame with 2:1 interlace, 30 frames or 60 fields per second, and 4:3 aspect ratio.

3.2 COLOR TELEVISION STANDARD²

The first NTSC was formed to perform a service specifically requested by the FCC and its advent was welcomed by the FCC. When the second NTSC was formed, a much less favorable situation existed. A non-compatible color system was approved by the FCC in 1950 against the advice of a great majority of the industry's technical experts. Because of the controversy, Dr. Baker reactivated the NTSC in January 1950.

The panel structure was reorganized around the particular problems of color television. The membership was greatly expanded. The work of the second NTSC was contained in 18 volumes of about 4,100 pages. Dr. Baker served as Chairman. The work of the second NTSC was divided among 8 panels.

Progress by several companies on color television research was rapid. Because of the rapid progress, on November 20, 1950 the activity of the eight panels was temporarily suspended and an Ad Hoc Committee was appointed to recommend a future course of action. The Ad Hoc Committee reported on April 19, 1951. Its recommendations were accepted and the second NTSC was reorganized into ten new panels. The first meeting of the reorganized NTSC was held June 18, 1951. By July 1953, when the Committee approved the final draft of the color signal specifications, all traces of the earlier controversy had disappeared and the industry was able to present a truly united front.

The color standard was adopted by the NTSC on July 21, 1953 and transmitted to the FCC the following day. Demonstrations were performed for the FCC on October 15, 1953. On December 17, 1953 the FCC approved the color standard. Color service was authorized after January 22, 1954. The second NTSC was officially disbanded on February 4, 1954.

² All the information in this section has been taken from Color Television Standards (Selected Papers and Records of the National Television System Committee), edited by Donald G. Fink, McGraw-Hill Book Company Inc., NY, 1955.

Only a few changes were made to the monochrome standard to include color. Of the key elements noted above for the monochrome standard, only the frame/field rate changed and that was by the ratio of 1000/1001.³ A modulated subcarrier containing the color information was added. The color burst was added to the synchronizing waveform. Some signal tolerances were made tighter.

3.3 ADVANCED TELEVISION SERVICE

A "Petition for Notice of Inquiry" was filed with the FCC on February 21, 1987 by 58 broadcasting organizations and companies requesting that the Commission initiate a proceeding to explore the issues arising from the introduction of advanced television technologies and their possible impact on the television broadcasting service. At that time, it was generally believed that High Definition Television (HDTV) could not be broadcast using 6 MHz terrestrial broadcasting channels. The broadcasting organizations were concerned that the alternative media would be able to deliver HDTV to the viewing public placing terrestrial broadcasting at a severe disadvantage.

The FCC agreed that this was a subject of utmost importance and initiated a proceeding (MM Docket No. 87-268) to consider the technical and public policy issues of ATV. On November 17, 1987 the FCC formed the Advisory Committee on Advanced Television Service. The Advisory Committee has filed five interim reports with the FCC. Key findings in those reports are summarized in this section.

3.3.1 First Interim Report, June 16, 1988

The first interim report was based primarily on the work of the Planning Subcommittee. The report noted that proposals to implement improvements in the existing NTSC television standard ranged from simply enhancing the current standard all the way to HDTV. The spectrum requirements for these proposals fell into three categories: 6 MHz, 9 MHz, and 12 MHz. Advocates of a 12 MHz approach suggested using two channels in one of two ways: 1) an existing NTSC-compatible channel supplemented by a 6 MHz augmentation channel (either contiguous or non-contiguous), or 2) an existing NTSC-compatible channel, unchanged, and a separate 6 MHz channel containing an independent non-NTSC-compatible HDTV signal. It was pointed out that both of these methods would be "compatible" in the sense that existing television receivers could continue to be serviced by an NTSC signal.

³ The color subcarrier was specified to be 1/2 an odd multiple (455) of the horizontal frequency to minimize the visibility of the subcarrier in the picture. To minimize beats between the sound carrier and the color subcarrier, the sound carrier was specified to be 1/2 an even multiple of the horizontal frequency. To

Just as rapid progress was seen by the second NTSC, rapid progress was seen by the Advisory Committee. In the first interim report, it was stated: "Based on current bandwidth compression techniques, it appears that full HDTV will require greater spectrum than 6 MHz." The report went on to say: "The Advisory Committee believes that efforts should be focused on establishing, at least ultimately, an HDTV standard for terrestrial broadcasting." The report also stated: "One advantage to [simulcasting], it should be noted, is that at some point in the future — after the NTSC standard and NTSC-equipped receivers are retired — part of the spectrum being utilized might be reemployed for other uses." On the basis of preliminary engineering studies, the Advisory Committee stated that it believed that sufficient spectrum capacity in the current TV allocations might be available to allow all existing stations to provide ATV through either an augmentation or simulcast approach.

3.3.2 Second Interim Report, April 26, 1989

The Advisory Committee suggested its life be extended from November 1989 to November 1991. It also suggested that the FCC should be in a position to establish a single terrestrial ATV standard sometime in 1992.

The Advisory Committee noted that work was ongoing in defining tests to be performed on proponent systems. An issue was raised relating to subjective tests and whether source material required for testing should be produced in only one format and transcoded into the formats used by different systems to be tested, or whether source material should be produced in all required formats.

The Advisory Committee also sought guidance from the FCC on the minimum number of audio channels that an ATV system would be expected to provide.

3.3.3 Third Interim Report, March 21, 1990

In the third interim report, it was noted that subjective assessment material would soon be shot. The Advisory Committee approved the test plans and agreed that complete systems, including audio, would be required for testing. It was also agreed that proposed systems must be pre-certified by SS/WP1 by June 1, 1990.

Because it was a deadline, the date of June 1, 1990 became quite significant. It is noteworthy that the first all-digital proposal was submitted shortly before June 1, 1990.

Other items mentioned in the third interim report were that the psychophysical tests of advanced television systems would be conducted in Canada; that the Planning Subcommittee, through its Working Party 3, would undertake the development of preliminary ATV channel allotment plans and assignment options; and that the Advisory Committee was not in a position to fund testing of consumer reactions to various aspects of ATV although PS/WP7 efforts to find other financing sources for such research projects was endorsed.

A review of current technology progress showed that there were no new concepts "sufficiently concrete so as to be tested contemporaneously with the pre-certified systems." The Advisory Committee stated that it believed that the five HDTV proponent systems then under consideration represented the state-of-available-technology.

The Advisory Committee noted that it was formed to counsel the FCC and proffer a recommendation on the best available ATV system. It said that other organizations are better suited to develop a completely specified technical standard. It also said it was the Committee's understanding that relevant discussions were underway among standards organizations and that an appropriate organization would volunteer to conduct this important assignment.

**4. CONTRIBUTIONS FROM THE PLANNING
SUBCOMMITTEE**

The Planning Subcommittee had the following Objective and Scope of Activity:

The statement of objectives stated:

The objective of the Working Party shall be to determine the desirable technical characteristics of ATV systems and to arrange and present this information in a form useful to the Planning Subcommittee and its Working Party. The Working Party will also work with and advise the Subjective Assessment and the Testing and Evaluation Working Parties on areas of particular interest for detailed examination. It will not be an objective of this Working Party to characterize or select any given system for recommendation to the Advisory Committee on Advanced Television Service for possible implementation.

The major contribution of the working party was an Attributes/Systems Matrix defining the attributes of an advanced television system that must be considered in selecting a terrestrial transmission advanced television service. The attributes matrix with explanatory notes is found as Annex I of the PS/WP1 final report.

The working party met several times with PS/WP2 (Working Party on Testing and Evaluation Specifications) in order to ensure that PS/WP2 was correctly interpreting the Attributes/Systems Matrix while defining their test plan.

The working party was Chaired by Renville H. McMann. The Vice Chairs were Stanley Baron, Thomas Keller, and Robert Niles. Forty-nine individuals participated in one or more of the meetings.

4.2 PS/WP2 - WORKING PARTY ON TESTING AND EVALUATION SPECIFICATIONS

PS/WP2 was charged with the development of objective test specifications for the ATV system attributes identified by PS/WP1 and to develop a draft schedule for the actual testing and evaluation of proposed ATV systems to be performed by the Systems Subcommittee.

PS/WP2 identified two types of testing which were subsequently adopted by the Advisory Committee:

Laboratory Testing to compare proponent system performance.

Field Testing to permit further investigation after laboratory tests are completed.

The completed conceptual test plan was forwarded to the Chairman of SS/WP2 on March 18, 1989. Necessary revisions since then were incorporated in the PS/WP2 final report as were documents created by the working party or submitted to it.

The working party was Chaired by Richard Green. The Vice Chairs were Edward Miller, Steve Flanagan, and William F. Schreiber.

4.3 PS/WP3 - WORKING PARTY ON SPECTRUM UTILIZATION AND ALTERNATIVES

PS/WP3 was given the responsibility for carrying out studies on the availability of spectrum to support various alternatives and systems for advanced television service.

To accomplish its mission, the working party divided its work into three fundamental parts. The first part dealt with the alternative of accommodating ATV within existing VHF and/or UHF television allocations. The second part dealt with the issues surrounding the alternative of accommodating ATV in the region of the spectrum above 1 GHz. The third and final part dealt with the possible impact of ATV on the spectrum utilization of various broadcast support and non-broadcast services.

With regard to the first part, the working party first developed and analyzed a series of spectrum scenarios reflecting various combinations of spectrum requirements. These early studies determined that existing allotments could be fully accommodated with additional ATV channels only if the minimum co-channel spacing was on the order of 160 kilometers (100 miles) and if there were no adjacent or taboo channel restrictions. The working party then developed (a) non-system-specific planning factors and (b) the methodology and computer model to permit the analyses of the service areas to be expected from each of the proposed ATV formats and the computation of further accommodation results.

Data specific to each of the proponent systems were then obtained from the testing laboratories, combined with the non-system-specific planning factors, and analyzed using the methodology/computer program noted above. These analyses produced the required accommodation and service area predictions which, in turn, provided elements necessary for the comparison of the five ATV simulcast systems.

With regard to the second part of its assigned responsibility, the working party largely suspended its investigation of the feasibility of accommodating ATV above 1 GHz when the Commission essentially ruled against such an alternative. With regard to the third part of its assigned responsibility, the working party carried out an extensive series of studies relating to the impact of ATV on spectrum requirements for the Broadcast Auxiliary Services (BAS). The working party concluded that it would be unlikely that compression techniques and fiber optic systems were feasible replacements for added BAS spectrum requirements for ATV transmission systems. It continued to urge the Commission to consider the allocation of additional spectrum for such purposes lest the advent of ATV systems be impeded.

The working party was Chaired by Dale Hatfield. The Vice Chairs were William Borman, Jules Cohen, and Donald Jansky.

4.4 PS/WP4 - WORKING PARTY ON ALTERNATIVE MEDIA TECHNOLOGY AND BROADCAST INTERFACE

The objective of PS/WP4 was to study and make recommendations regarding the relationship of terrestrial advanced television systems to alternative media, applications and standards. It was also the objective to investigate approaches for growth paths to the future while, at the same time, to support timely decisions on an ATV broadcast system with increased performance quality for the end user. PS/WP4 addressed issues related to interoperability, scalability, extensibility, and more generally, openness. Representatives of the broadcast television, cable television, program production, motion picture, computer, telecommunications, and imaging industries were active in this working party.

During 1991, PS/WP4 developed definitions of key terms such as interoperability, scalability and extensibility. Based upon a world becoming more complex and richer in alternatives (media, transmission/distribution, presentations), the working party developed the concept of image data, defined as the digital equivalent of the video information including image, sound and auxiliary data components.

Once SS/WP4 established the ten selection criteria, PS/WP4 adjusted its focus to concentrate on the three criteria that related to alternative media: Interoperability, Scope of Services and Features, and Extensibility.

An assessment of the five proponent systems in reference to the above three criteria was made by PS/WP4. The working party developed a layered architectural model¹ for ATV to aid in evaluating the proponent systems along with applications and performance questions on these criteria. Participants of PS/WP4 employed a technical consultant, StellaCom, Inc., to assist in this analysis. The assessments were based upon information supplied by each of the proponents in (1) published form, (2) response to specific PS/WP4 questions, and (3) a three-day Interoperability Review involving the proponents and a special Interoperability Review Board (convened specifically for evaluation of the proponent systems relative to the three criteria and conducted in September 1992). The Review Board consisted of experts across a broad array of relevant disciplines. The selected experts had no relationship to any of the system proponents. Results of the Review Board evaluation weighed heavily in the PS/WP4 conclusions and recommendations.

PS/WP4 identified a number of characteristics that contribute significantly to Interoperability, Scope of Services and Features, and Extensibility. These were based on needs and desires exhibited by alternative media advocates, not only for the delivery of terrestrial broadcast television programming, but also for other delivery approaches and applications relating to

¹ Similar to the Open Systems Interconnect (OSI) model for data communications developed by the International Organization for Standardization (ISO).

computing, communications, motion pictures, and imaging. In relative order of importance, these characteristics are:

An all-digital implementation based on a layered architecture model;

The use of universal headers and descriptors (as agreed by an industry standards group, for example, SMPTE);

Transmission of the signal in progressive scan format;

Use of a flexible, packet data transport structure;

Viewer transparent channel re-allocation (limited picture and sound while most of the channel capacity is devoted to data transmission for conditional access addressing or other purposes);

Ability to implement lower-performance, low-cost ATV receivers (comparable price/performance options to current NTSC receivers);

Ability to implement a low-cost ATV consumer VCR;

System architecture and implementation that will allow improvements and extensions to be incorporated as technology advances while maintaining backward compatibility;

Square pixels, or at least the option to select square pixel presentation;

Compatibility with relevant international standards, or commitment to this objective; and

Easily-implementable and user-accessible "still/motion multi-window transmission."

Specific recommendations regarding these characteristics are included in the PS/WP4 final report.

The PS/WP4 Working Group on Satellite Testing was formed to study the compatibility of the terrestrial ATV systems with satellite transmission for broadcasting and direct-to-home applications.

The working group based its evaluation on paper studies using proponent information supplied in response to a questionnaire and "Reference Link Models" which the working group developed.

Conclusions were reached on the compatibility of ATV systems with Fixed Satellite Service (FSS) and Broadcasting Satellite Service (BSS) satellite delivery, and commercially available uplink and downlink earth station equipment.

Conclusions also were reached on delivery of ATV programming to small aperture home satellite antennas. Interference from adjacent satellites and from terrestrial Fixed Service microwave operations at C-band proved to be important issues.

The working group also concluded that some form of Automatic Transmitter Identification System (ATIS) is desirable.

The working party was Chaired by Edward D. Horowitz. The Vice Chairs were Virgil Conanan, Paul Heinerscheid, Paul Resch, and Robert L. Sanderson.

4.5 PS/WP5 - WORKING PARTY ON ECONOMIC FACTORS AND MARKET PENETRATION

The primary task of PS/WP5 was to develop a projection of the rate of growth of the market penetration of high definition equipment in television households.

Over the life of PS/WP5, four such projections were developed, each changing as new or refined assumptions were made, and as the supporting technology matured. As a starting point, the historic growth in market penetration achieved by other consumer electronic products was studied to determine whether it might be analogous to the growth of ATV.

Later work of PS/WP5 led to a refined projection of market penetration. It was based on an assessment of the perceived incremental value to the consumer of ATV compared with the present television service. High and low perceived values were projected since no comprehensive audience research program was possible for lack of funding.

Similarly, a high and low range of consumer equipment prices were developed, because no definitive prices had yet been established, pending the selection of a transmission standard.

The discretionary income of the consumer applied to the purchase of current video services was assumed to be the source of funding for HDTV purchases, becoming available over a period of years. This funding level corresponded to a high perceived value by the consumer. A lesser fund for the purchase of equipment was assumed in the event that the perceived value of HDTV was much lower.

With these projections in hand, the number of units of HDTV equipment which could be purchased was calculated for each of the ten years following the selection of a transmission standard by the FCC. In this way the growth in the number of HDTV households having one or more of the potential HDTV delivery services of broadcast, cable, home video, or DBS, could be plotted.